CROSS ENTERPRISE NEEDS FOR IN-SPACE FABRICATION & REPAIR

Code U Workshop on
In-Space Fabrication & Repair

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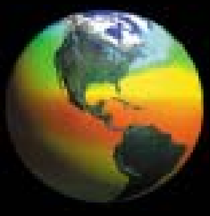
Outline

- Code R Technology Program
- Enterprise Needs for In-Space Fabrication & Repair
- Modular Systems
- Code R NRAs

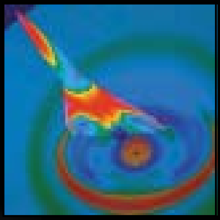
6 Strategic Enterprises One NASA


Space Science


Earth Science


Biological & Physical Research


Space Flight


Aerospace Technology


Education

NASA's Vision

- To improve life here
- To extend life to there
- To find life beyond

NASA's Mission

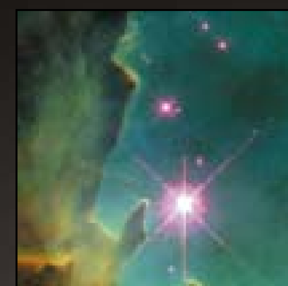
- To understand and protect our home planet
- To explore the universe and search for life
- To inspire the next generation of explorers

…as only NASA can

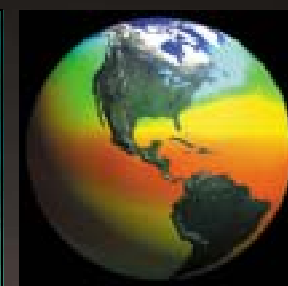
The Aerospace Technology Enterprise Contributes to the NASA Vision and Mission through Technology Development and Transfer

NASA's Vision

OGA & Industry Partners



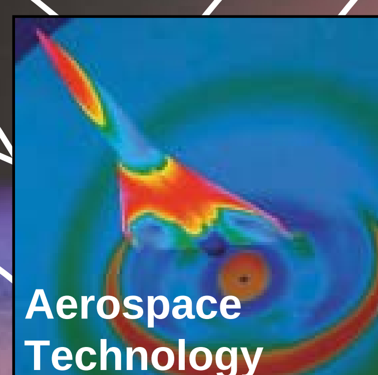
Space Science

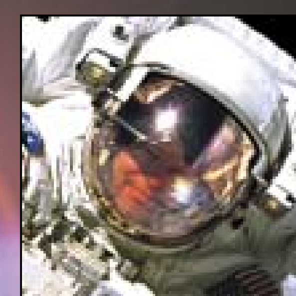


Earth Science

Biological & Physical Research

Non Aerospace Industry & Educators

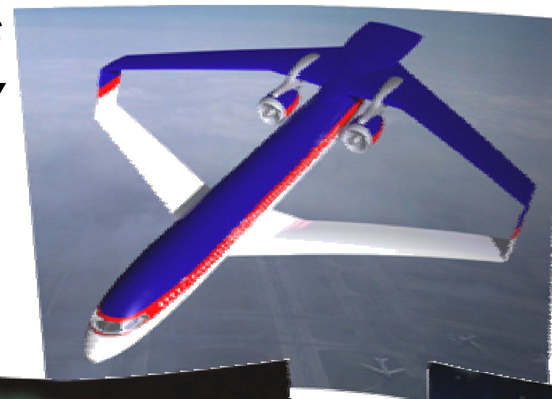




Space Flight

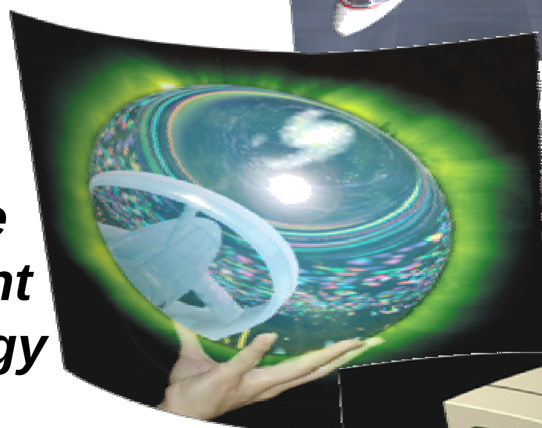
Aerospace Technology Enterprise
Strategic Themes

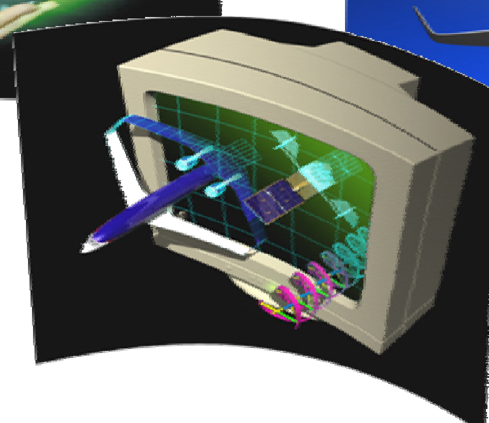
Aeronautics Technology



Space Launch Initiative

Mission and Science Measurement Technology





Innovative Technology Transfer Partnerships

Mission & Science Measurement Technology

Strategic Theme Objectives and Programs

Theme Objectives

Mission Risk Analysis

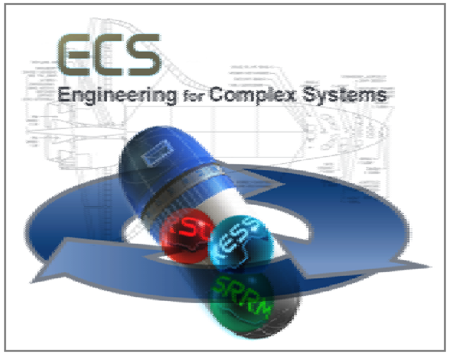
Develop the capability to assess and manage risk in the synthesis of complex systems.

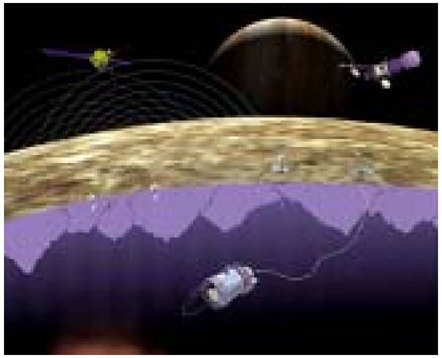
Science Driven Mission Architectures and Technology

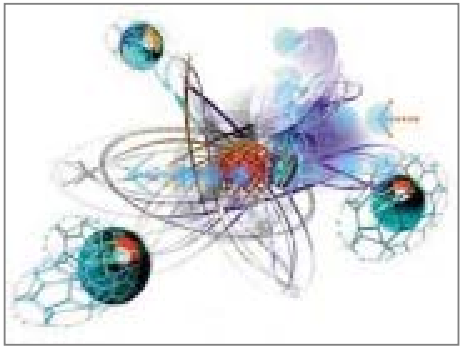
Define new system concepts and demonstrate new technologies which enable new science measurements.

Create Knowledge from Scientific Data

Develop break-through information and communication systems to increase our understanding of scientific data and phenomena







Programs

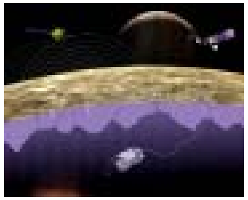
Engineering for Complex Systems

Enabling Concepts & Technologies

Computing, Information & Communications Technology

Enabling Concepts & Technologies Program

Projects

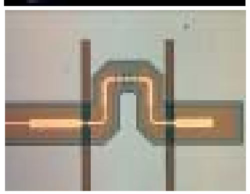


Advanced System Concepts

Conceptual studies and systems analysis of revolutionary aerospace system concepts that have the potential to leap well past current plans, or to enable new visions for NASA's strategic plans.

Energetics

Development of advanced power and propulsion technologies to enable lower-cost missions with increased capability, and to extend mission reach.

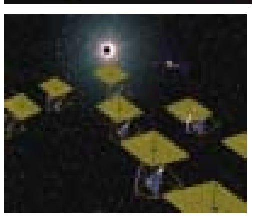


Advanced Measurement and Detection

Development of miniaturized, highly-integrated, and efficient instruments and sensors to provide increased scientific return.

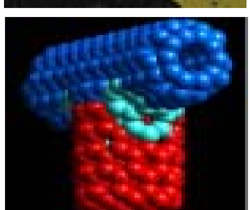
Revolutionary Spacecraft Systems

Development of revolutionary spacecraft systems and architectures to enable distributed science data collection, explore extreme environments, and lower mission costs.



Large Space Systems

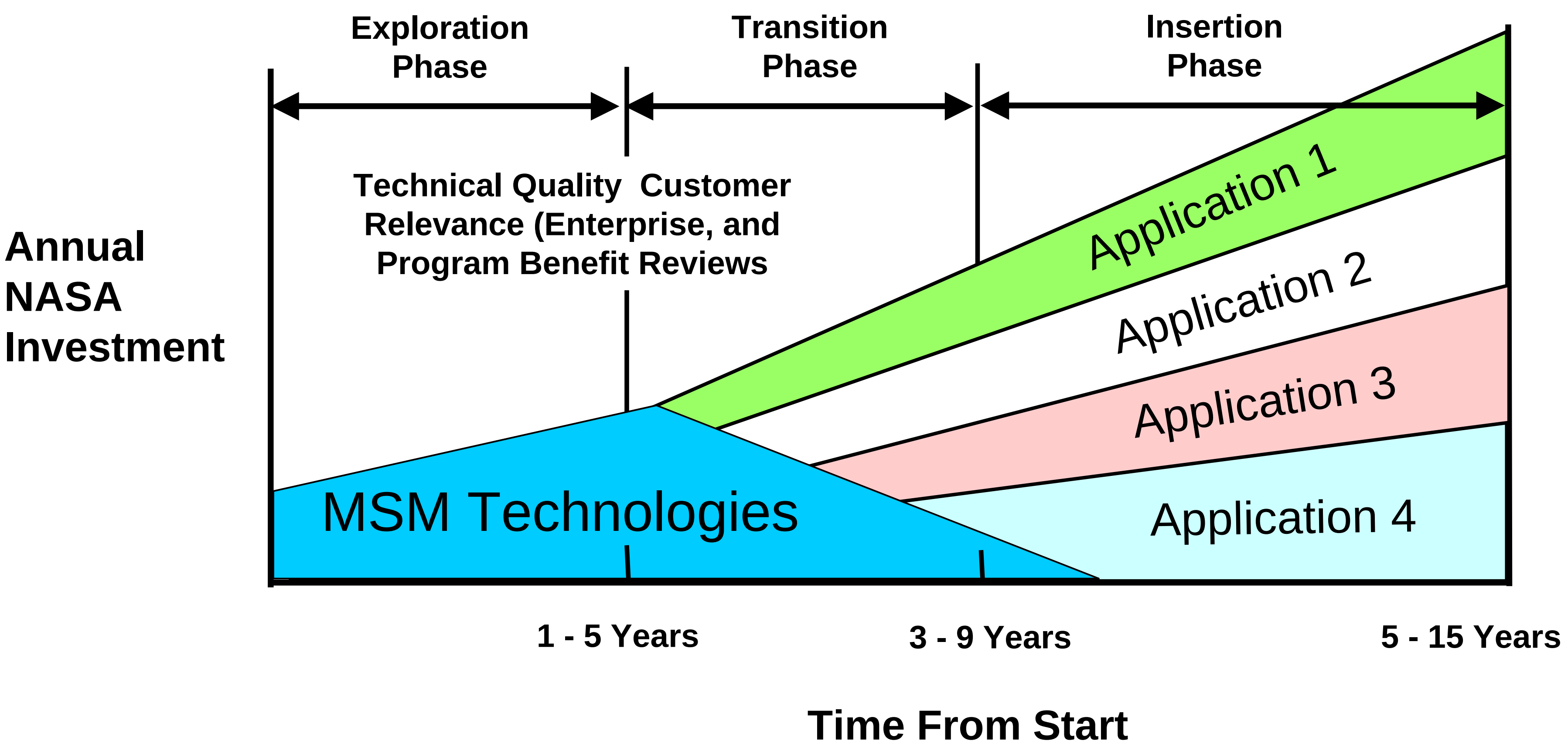
Development of concepts for large, ultra-lightweight space structures and apertures to expand mission capabilities, and enable new visions of the Earth and the Universe.



Space NRAs

Broadly announced peer-reviewed solicitations to capture innovative ideas from external organizations, to leverage high-payoff emerging technologies, and to complement NASA capabilities in critical areas.

The Big Picture - Where MSM Fits



Addressing Enterprise Technology Needs

- Code R has established a Technology Executive Board (TEB)
  - Membership - Enterprise Technology Representatives
  - Defines a joint list of Enterprise technology needs and priorities
  - Provides guidance on program content and direction

Code S

– Sensors and instruments
☞ Advanced optical systems
– Robotic systems
– High strength-to-weight materials
– Advanced propulsion
– Formation flying
– Extreme environments

Code M

☞ Large space solar power systems
– High power propulsion
☞ Modular infrastructures
☞ Assembly, maintenance, & servicing
– Lighter, more flexible EVA with extended duration

Code Y

– Lasers and lidar
☞ Large telescopes & antennas
– Frequency agile detectors
– Microwave transmitters & receivers
– High efficiency solar cells
– Miniature guidance & navigation sensors

Code U

– Autonomous environmental monitoring & control
– In-space medical diagnostics
– Spectroscopy for space biology research
– Biomolecular sensors to support crew health & safety
– Lighter, more flexible EVA with extended duration
☞ In-space manufacturing & fabrication

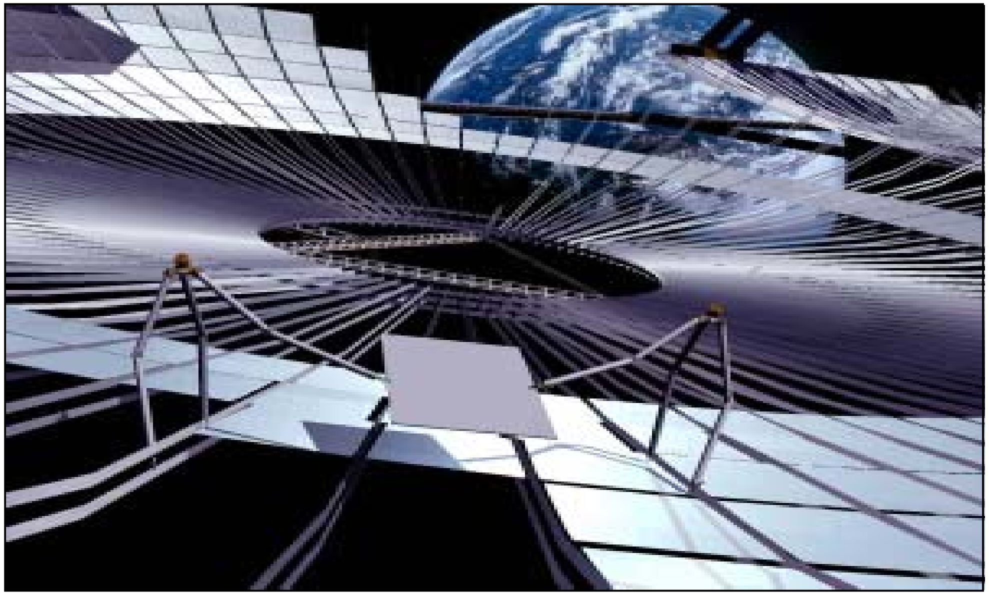
☞ *Mission applications for in-space fabrication & assembly*

Grand Challenge - In Space Assembly

Human/robot teams construct large orbital systems for science and exploration.

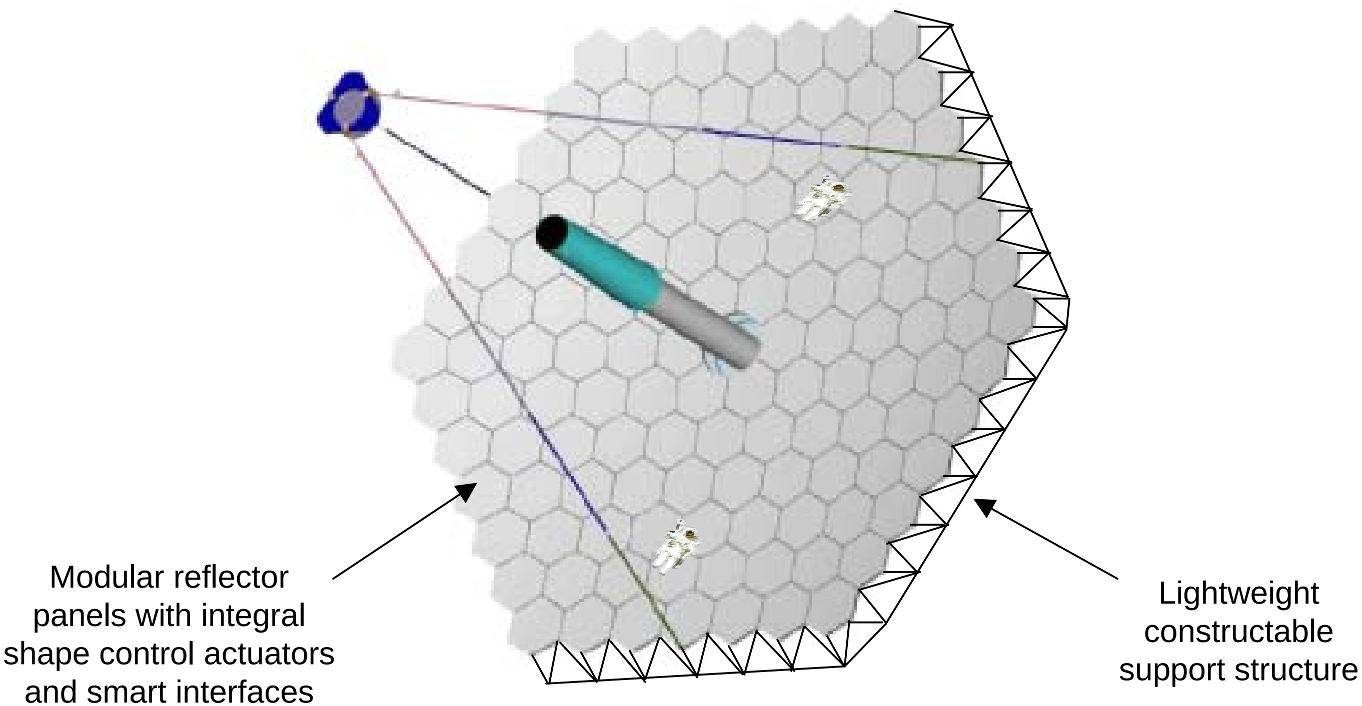
Scenarios

- Construction of astronomical observatories and space science platforms at Lagrange points (L1, L2)
- Construction of large Earth observation platforms in distant vantage points (GEO, L1, L2).
- Assembly of space infrastructure for human exploration
- Assembly of large space utilities to collect and transmit solar power
- Assembly and maintenance of interplanetary space probes.



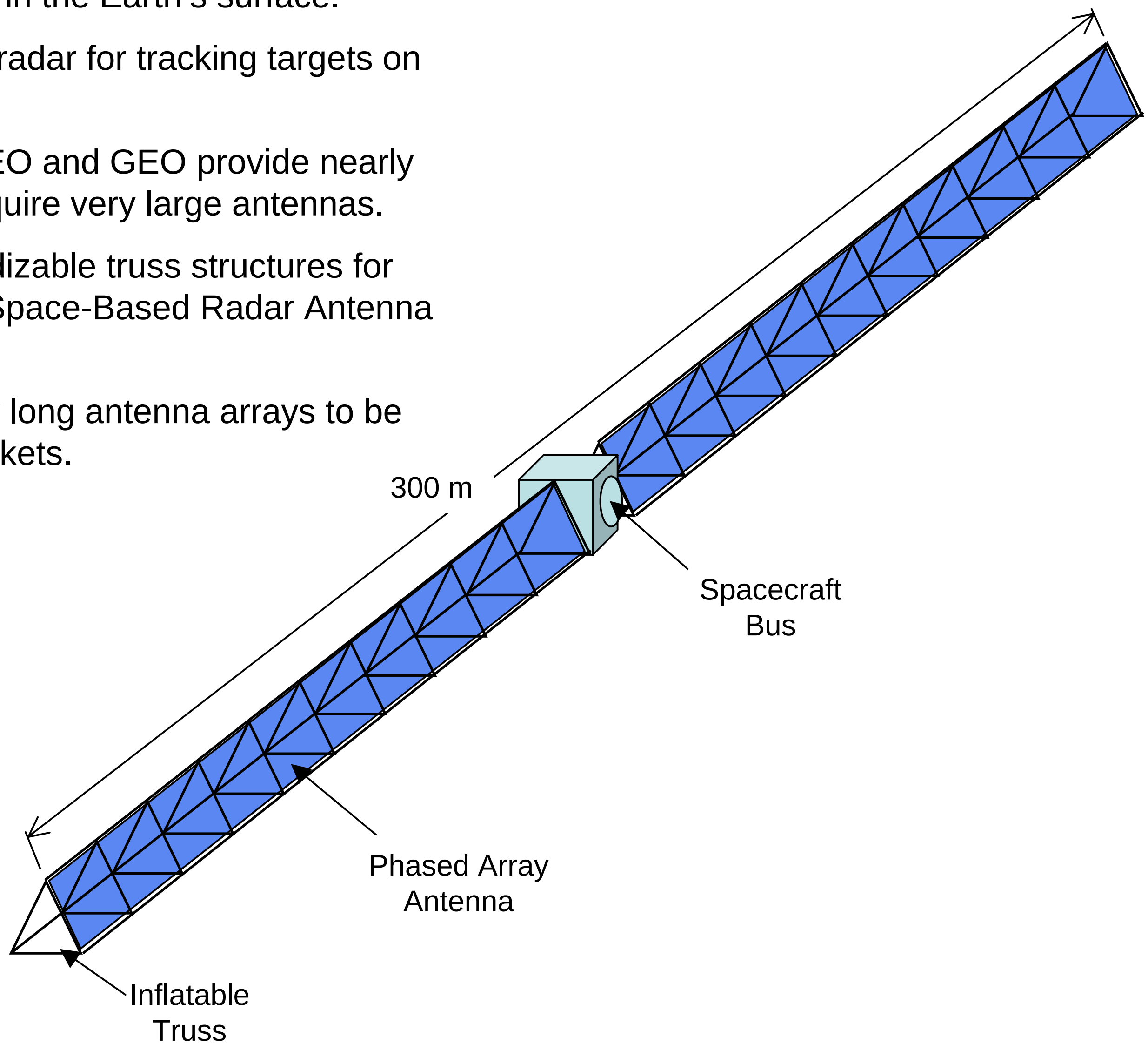
Large Telescopes

- Assembly of large telescopes from modular building blocks will enable 50-meter class apertures for detecting extrasolar planets and studying the early universe.
- In-space fabrication of structural elements reduces launch volume
- Modularity allows aperture size to be expanded in stages to increase scientific capabilities
- Modularity allows replacement of damaged reflector panels.



Large Antennas

- Earth Science Enterprise is interested in space-based radar observatories for mapping changes in the Earth's surface.
- DoD is interested in space-based radar for tracking targets on the ground from orbit.
- Space-based radar systems in MEO and GEO provide nearly continuous global coverage, but require very large antennas.
- NASA is developing inflatable rigidizable truss structures for the DARPA-sponsored Innovative Space-Based Radar Antenna Technology (ISAT) program.
- In-space fabrication will allow very long antenna arrays to be launched on smaller, lower-cost rockets.

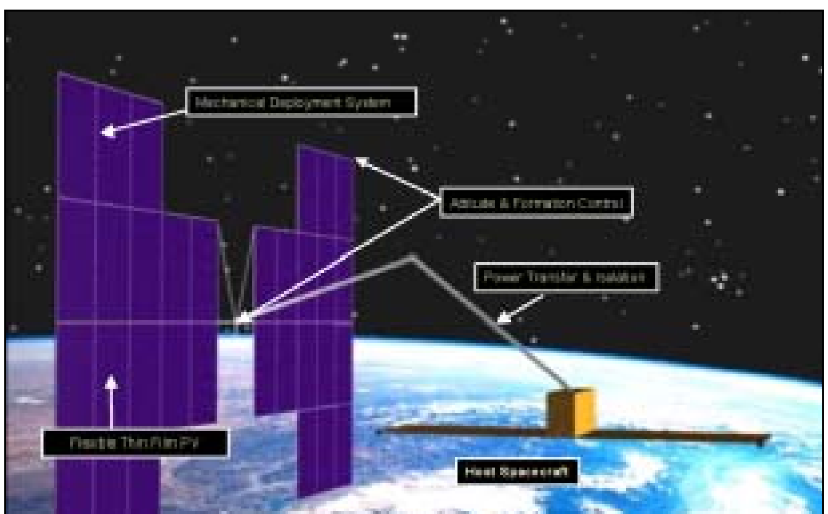


Space Infrastructure

- Expanding human presence in space will require a more complete infrastructure to support human activities and enable science activities
- The existing on-orbit infrastructure is limited by payload bay size, mass limits on launch vehicles, and the few options available for assembling on-orbit components.
- The complexity of on-orbit activities will be directly related to the infrastructure available in space to support a broader range of missions.
- Critical Technology Needs:
  - Enable the assembly of space infrastructure from intelligent modular elements.
  - Reduce amount of on-orbit crew time dedicated to infrastructure maintenance and servicing
  - Improve reliability and safety of overall operations by using automated inspection tools and orbital servicing components directed from the ground
  - Produce spare parts on demand instead of stocking a large inventory for all possible contingencies.

Space Solar Power Systems

- Very large systems for the collection, conversion, and transmission of solar power.
- Applications include abundant power for satellites, in-space transportation, surface systems, and terrestrial utilities.
- In-space fabrication needed for modular assembly and repair of:
  - Primary structure
  - Solar arrays
  - Microwave transmitting antenna
  - Solar reflectors and concentrators
  - Radiators and thermal management

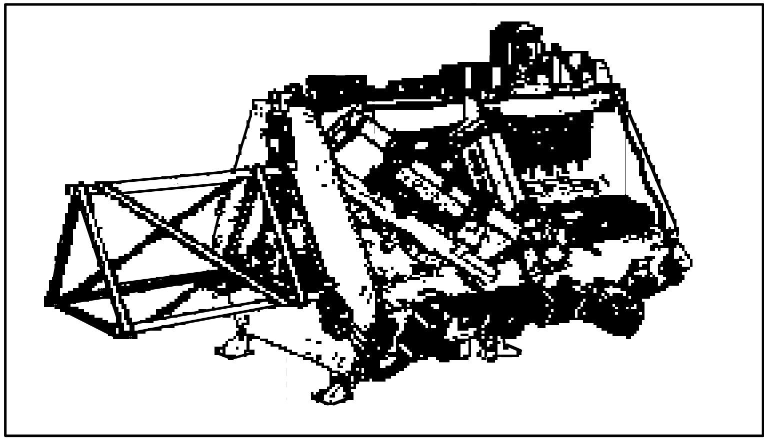


AFRL PowerSail concept for large membrane solar array flying in formation with nearby spacecraft

Kilometer-scale space solar power station uses microwaves or lasers to beam power

Structural Elements for In-Space Assembly

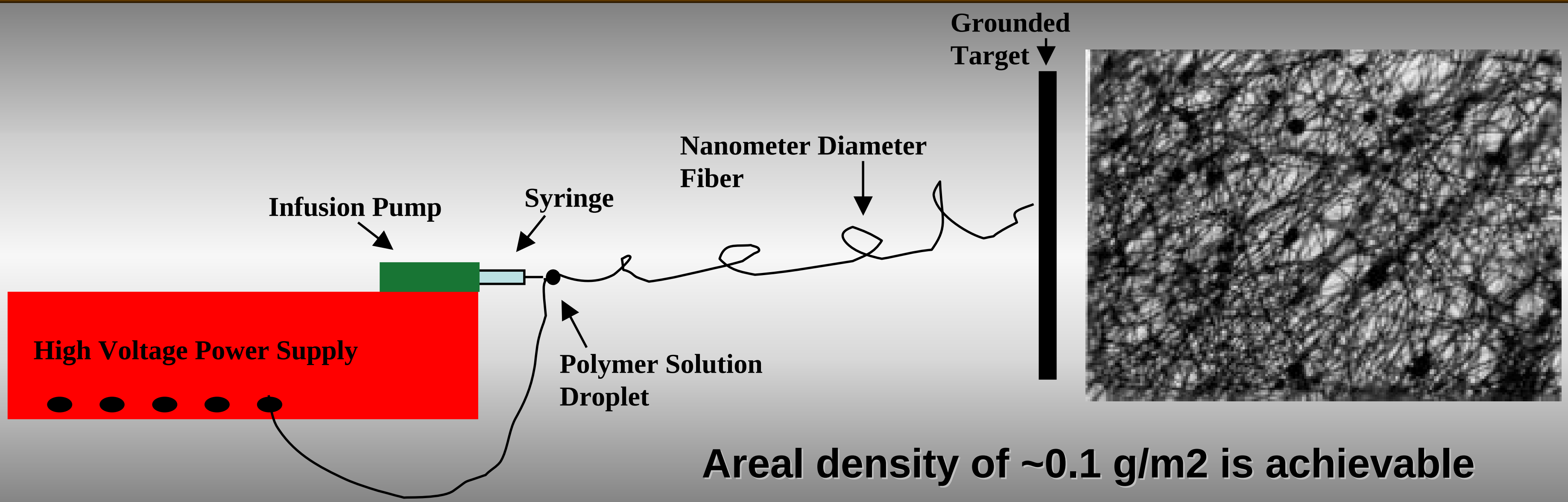
- Inflatable and deployable truss segments.
- Beam builders fabricate lightweight beams from aluminum or composite feedstock.
- Human/robotic cooperative assembly join truss segments together to form larger girders and support structures.
- Smart interfaces for structural, electrical, and fluid connections enable plug-in functionality and reconfigurability.



Grumman beam builder

Inflatable Truss

Electrospinning of Nanofibers

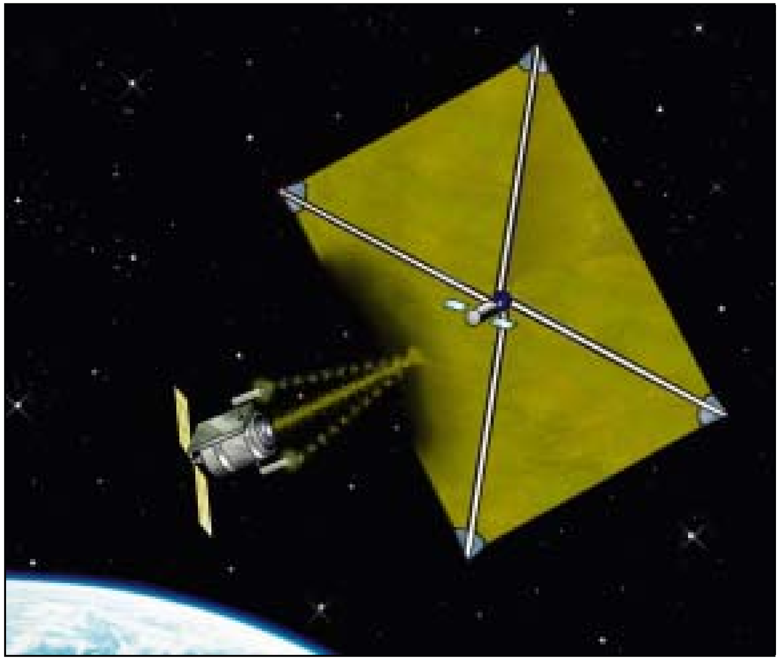


Areal density of ~0.1 g/m2 is achievable

- Process provides small diameter (10-100 nm) fibers distributed in a non-woven mat
- Performed on many different polymer systems.
- Potential to provide significant weight reduction without sacrificing strength (i.e. higher strength at lower densities)
- Alternative form of solar sail material (non-woven mat)

In-Space Membrane Fabrication

- Very large solar sails are needed to provide continuous thrust for stationkeeping in unstable orbits, or for high energy missions such as interstellar probes.
- Areal density drives solar sail performance.
- Very large (> 100 m), ultra-thin sails probably cannot be deployed.
- In-space fabrication of membranes by electrospinning or other methods may enable ultra-lightweight sails.
- In-space repair of torn membranes may be useful.

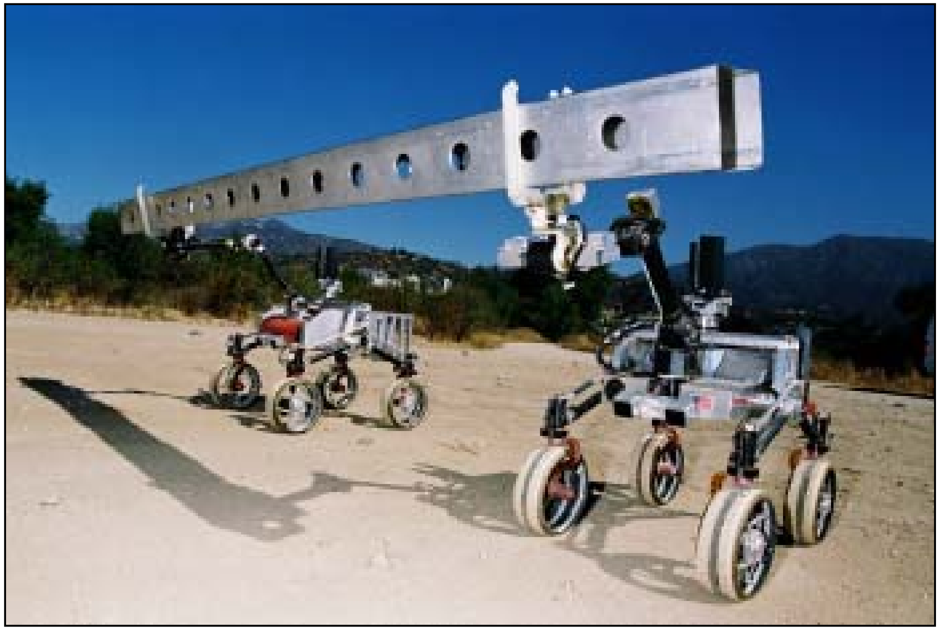


Grand Challenge - Surface Assembly

Construct and maintain facilities for scientific exploration on the surface of the Moon or other planetary bodies

Scenarios

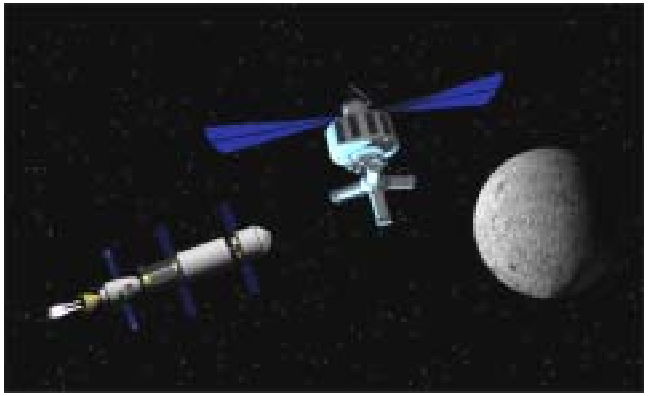
- Construction of very large observatories on the moon
- Pre-deployment of surface systems for human exploration of Mars
- Preparation of long-term planetary science bases
- Utilization of in-situ resources for fabrication



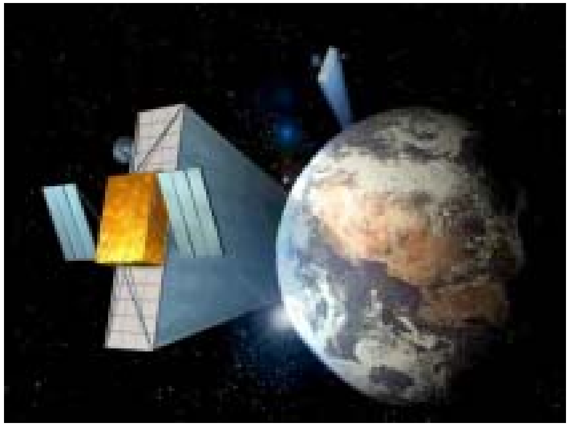
In-Space Repair

- In-space repair can enable significant reductions in mission risk by:
  - Repairing impact damage to vehicle systems
  - Fabricating spares to replace failed components
  - Extending the useful lifetime of operational satellites

Modular Systems Technology Will Address Multiple Enterprise Needs

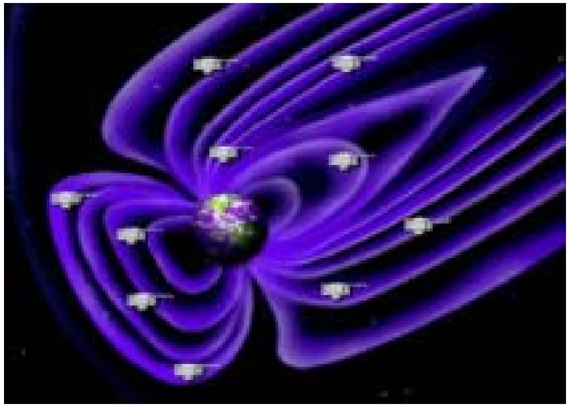


Space Infrastructure for Human Exploration



Space-Based Radar

Large Telescopes



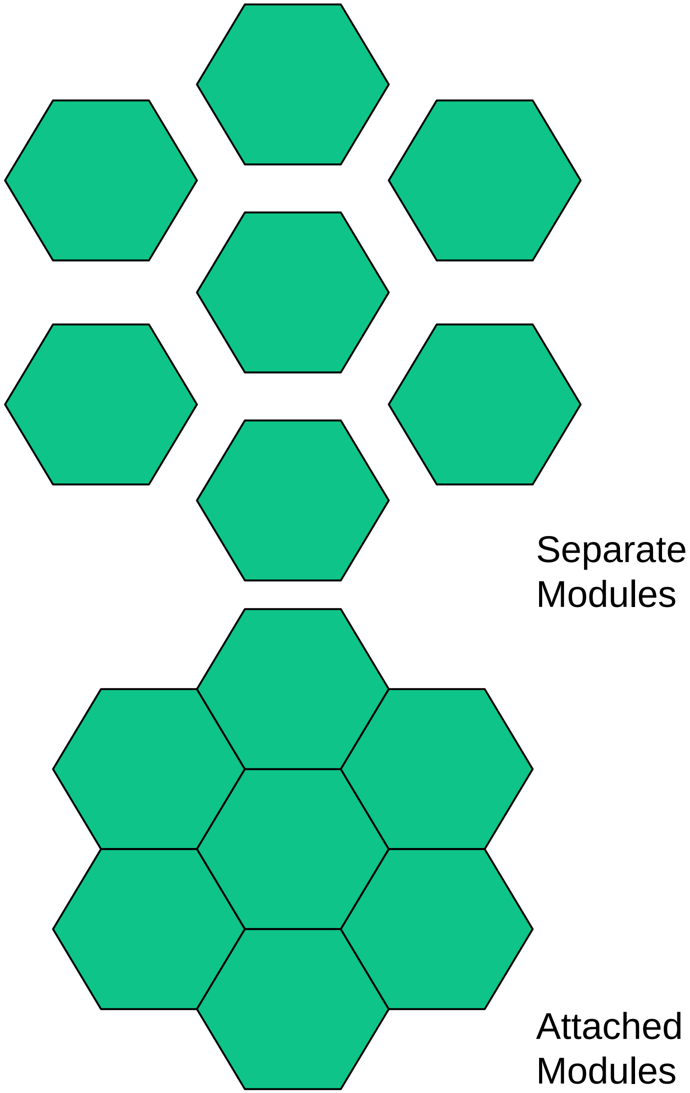
Distributed Science Collection

Advanced Propulsion Systems

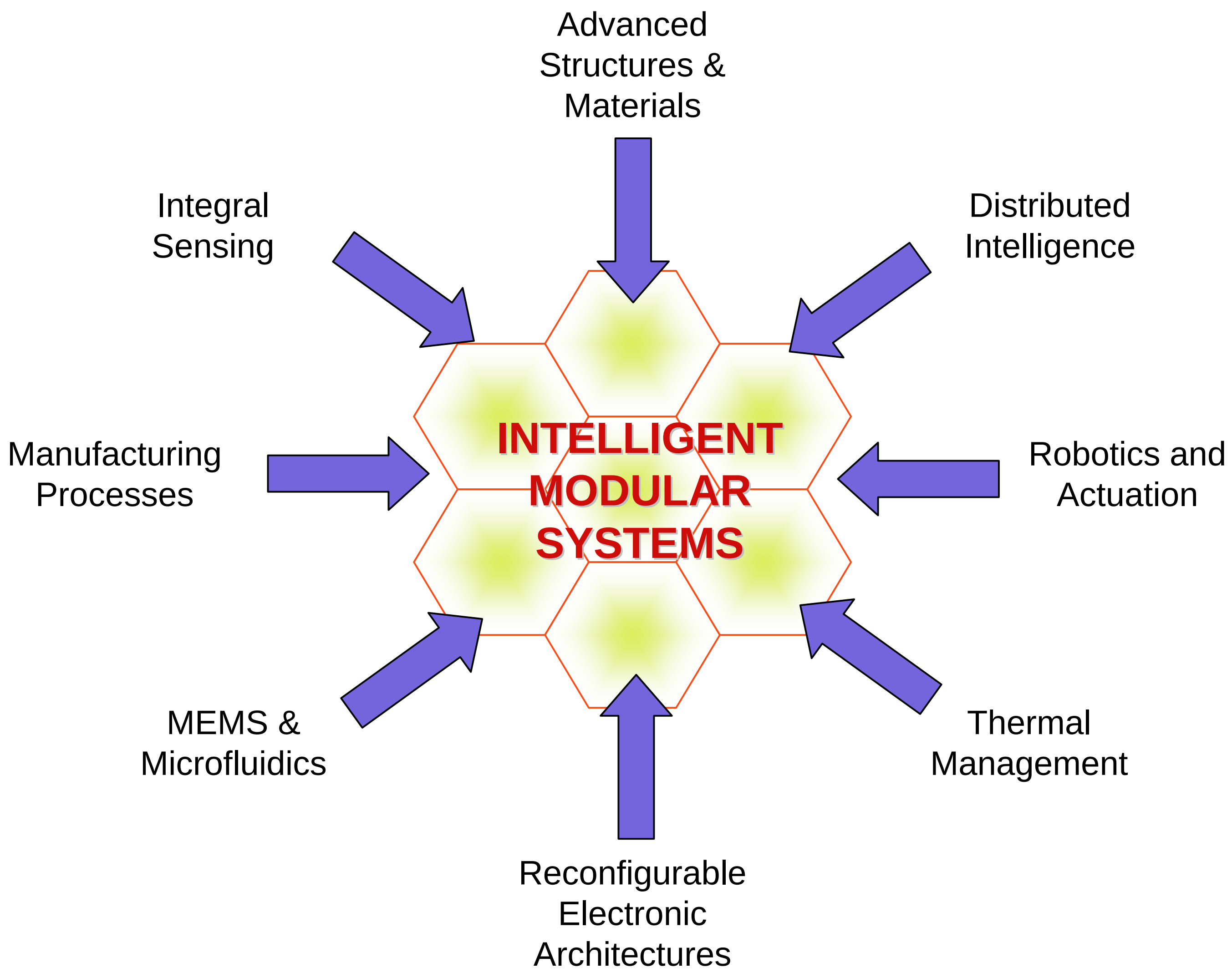
Space Power Systems

What is an Intelligent Modular System?

- A modular system is a collection of similar elements that grows in capability as more elements are added.
- A modular system embodies distributed intelligence. Each element is smart, and can be configured to perform a variety of different functions in the overall system.
- The elements of a modular system can be either separate or attached. The elements interact via the exchange of signals, or through physical connections.
- An intelligent modular system is robust and adaptive. Elements can be replaced, or system functions can be reconfigured in response to changing mission conditions.



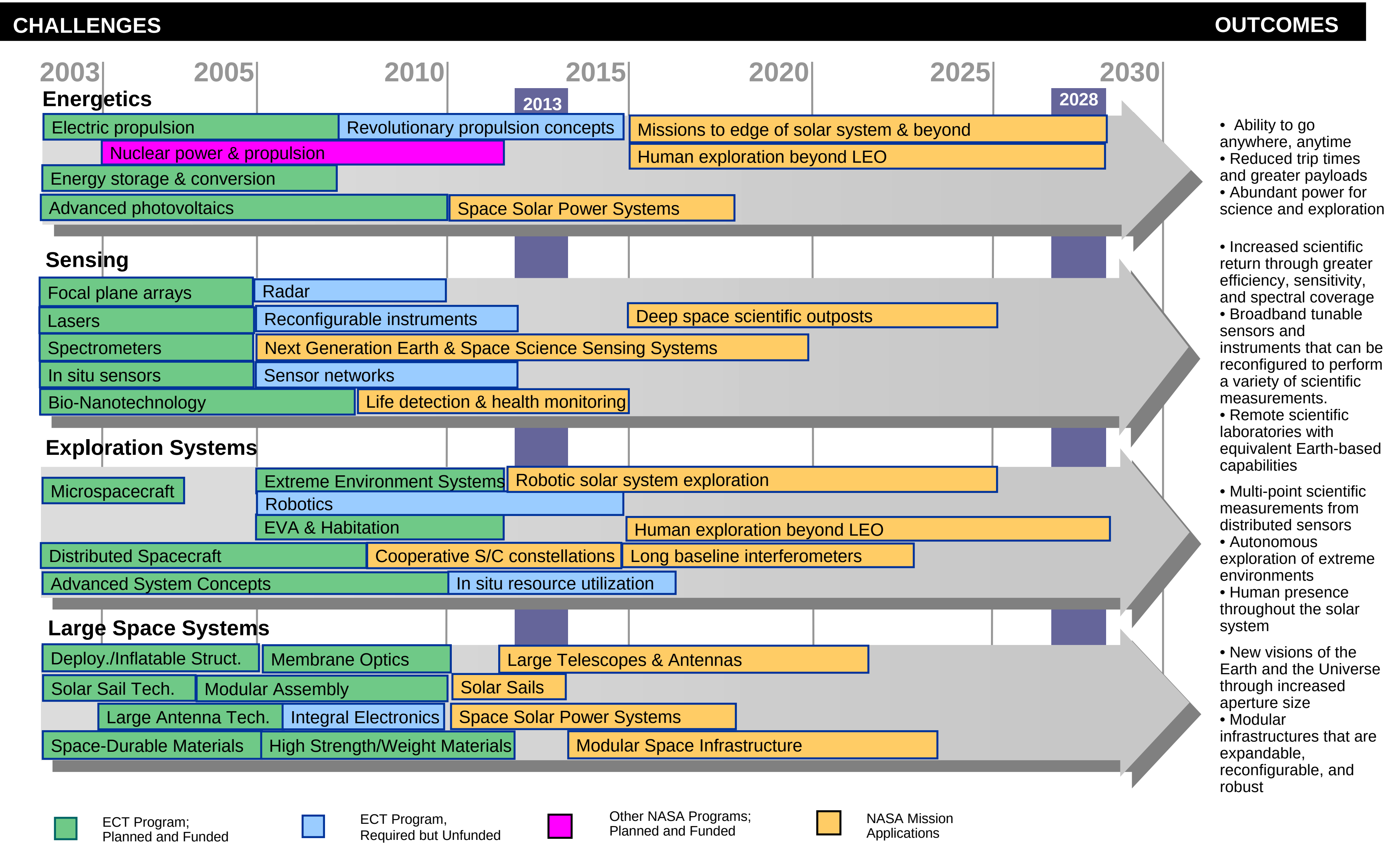
Intelligent Modular Systems Incorporate Multiple Technologies



Objective 10.2: Science Driven Mission Architectures and Technology

Create system concepts and demonstrate technologies that enable new scientific measurements.

Benefits:
- Increased scientific return
- Enable missions and capabilities that are currently unachievable
- Breakthrough reductions in mission cost
- New visions for NASA's strategic plans



Code R NASA Research Announcements

- Code R will issue a $39M NASA Research Announcement (NRA) for Mission and Science Measurement Technology on August 4.

- The NRA will include three main technology areas in response to Enterprise priorities:
  - Advanced Measurement & Detection
    - focal planes, cryocoolers, lasers, in-situ micro-instruments
  - Large Apertures
    - lightweight optical systems, deployable antennas, wavefront control
  - Low Power Electronics
    - microprocessors, A/D converters

- Draft NRA is posted the web for public comment at:
  http://research.hq.nasa.gov/

- Bidders Conference will be held at University of Maryland Conference Center on July 15.

- NRA is open to all categories of organizations, including industry, universities, non-profit institutions, NASA Centers, and other government agencies.

- Typical funding awards are $300K - $500K per year for 3 years.

Summary

- Modularity is a unifying theme that ties together technology development for a wide range of Enterprise mission needs.

- In-space fabrication, assembly, and repair are crosscutting technologies that will enable modular systems.